REMARKS

Claims 1, 3 and 5 through 16 are amended. Thus, claims 1 through 16 are presented for examination as amended.

Claim amendments have been made to eliminate element numbering and multiple dependencies. No new matter is added by the changes made herein.

Respectfully submitted,

Elliott N. Kramsky
Registration 27,812
Attorney for Applicant

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Title: METHOD FOR ELECTRONIC TUNING OF THE READ OSCILLATION FREQUENCY OF A CORIOLIS GYRO

Inventor: Werner Schroeder

BACKGROUND

Field of the Invention

The present invention relates to Coriolis gyros. More particularly, this invention pertains to a method for electronic tuning of read oscillation frequency to stimulation oscillation frequency in such a device.

~~The invention relates to a method for electronic tuning of the frequency of the read oscillation to the frequency of the stimullation oscillation for a Coriolis gyro.~~

Description of the Prior Art

Coriolis gyros~~,~~ (~~which are~~ also known ~~referred to~~ as "vibration gyros") are increasingly employed ~~being used to an increasing extent~~ for navigation ~~purposes, they have~~ . Such devices include a mass system that ~~which~~ is caused to oscillate. Such ~~This~~ oscillation is generally a superimposition of a large number of individual oscillations. The ~~These~~ individual oscillations of the mass system are initially independent of one another and ~~can~~ each may be regarded in the ~~an~~ abstract ~~form~~ as a "resonator" ~~resonators~~. At least two resonators are required for operation of a vibration gyro~~. one of these resonators~~ . A first resonator is artificially stimulated to oscillate, with such ~~these~~ oscillations ~~being~~ referred to below ~~in the following text~~ as a "stimulation oscillation". A ~~the~~ second resonator is stimulated to oscillate only when the vibration gyro is moved or rotated. That is ~~Specifically~~, Coriolis forces occur ~~in this case~~ which couple the first resonator

to the second resonator, draw energy from the stimulation oscillation of the first resonator, and transfer the ~~this~~ energy to the read oscillation of the second resonator. The oscillation of the second resonator is referred to below ~~in the following text~~ as the "read oscillation". In order to determine movement ~~movements~~ (in particular rotation ~~rotations~~) of the Coriolis gyro, the read oscillation is tapped off and a corresponding read signal (e.g. ~~for example~~ the tapped-off read oscillation signal) is analyzed ~~investigated~~ to determine whether any changes ~~have~~ occurred in the amplitude of the read oscillation that measures ~~which represent a measure for the~~ rotation of the Coriolis gyro. Coriolis gyros may be in the form of either ~~both~~ an open loop ~~system and~~ or a closed loop system. In a closed loop system, the amplitude of the read oscillation is continuously reset to a fixed value (preferably zero) by ~~via respective~~ control loops.

~~In order to further illustrate the method of operation of a Coriolis gyro, one example of a closed loop version of a Coriolis gyro will be described in the following text, with reference to Figure 2.~~

Figure 2 is a schematic diagram of a closed loop Coriolis gyro 1. The ~~A Coriolis~~ gyro 1 ~~such as this~~ has a mass system 2 that can be caused to oscillate and is referred to below as a ~~and which is also referred to in the following text as a~~ resonator 2 (in contrast to ~~This expression must be distinguished from~~ the "abstract" resonators, ~~which have been~~ mentioned above, which represent individual oscillations of the "real" resonator). As already mentioned, the resonator 2 may be regarded as a system composed of two "resonators" (a first resonator 3 and a second resonator 4). Each of ~~Both~~ the first and ~~the~~ second resonators ~~resonator~~ 3, 4 is ~~are each~~ coupled to a

force transmitter (not shown) and to a tapping-off system (not shown). ~~The~~ Noise ~~which is~~ produced by the force transmitter and the tapping-off system ~~systems~~ is ~~in this case~~ indicated schematically by ~~the~~ noise 1 (reference symbol 5) and ~~the~~ noise 2 (reference symbol 6).

The Coriolis gyro 1 includes ~~furthermore has~~ four control loops. A first control loop is employed ~~used~~ for controlling the stimulation oscillation (i.e. the frequency of the first resonator 3) at a fixed frequency (resonant frequency). The first control loop has a first demodulator 7, a first low-pass filter 8, a frequency regulator 9, a VCO (voltage controlled oscillator) 10 and a first modulator 11. A second control loop controls ~~is used for controlling~~ the stimulation oscillation at a constant amplitude and includes ~~has~~ a second demodulator 12, a second low-pass filter 13 and an amplitude regulator 14.

Third and fourth control loops are used for resetting ~~those~~ forces that ~~which~~ stimulate the read oscillation. ~~In this case,~~ The third control loop includes a third demodulator 15, a third low-pass filter 16, a quadrature regulator 17 and a second modulator 18. The fourth control loop comprises ~~contains~~ a fourth demodulator 19, a fourth low-pass filter 20, a rotation rate regulator 21 and a third modulator 22.

The first resonator 3 is stimulated at its resonant frequency $\omega 1$. The resultant stimulation oscillation is tapped off, ~~is~~ demodulated in phase by means of the first demodulator 7, and a demodulated signal component ~~is~~ passed to the first low-pass filter 8 that removes the sum frequencies ~~from it~~. The tapped-off signal is ~~also~~ referred to below ~~in the following text~~ as the

tapped-off stimulation oscillation signal. An output ~~signal~~ from the first low-pass filter 8 is supplied to a frequency regulator 9 that ~~which~~ controls the VCO 10 as a function of the applied signal ~~that is supplied to it~~ so that the in-phase component essentially tends to zero. For this ~~purpose~~, the VCO 10 sends ~~passes~~ a signal to the first modulator 11, which ~~itself~~ controls a force transmitter so that a stimulation force is applied to the first resonator 3. When ~~If~~ the in-phase component is zero, the first resonator 3 oscillates at its resonant frequency ω1. It should be mentioned that all of the modulators and demodulators are operated on the basis of ~~this~~ resonant frequency ω1.

The tapped-off stimulation oscillation signal is also ~~furthermore~~ passed to the second control loop and ~~is~~ demodulated by the second demodulator 12. The ~~whose~~ output of the second demodulator 12 is passed through the second low-pass filter 13, whose output signal is, in turn, applied ~~supplied~~ to the amplitude regulator 14. The amplitude regulator 14 controls the first modulator 11 as a function of such ~~this~~ signal and of a nominal amplitude transmitter 23 such that the first resonator 3 oscillates at a constant amplitude (i.e. ~~that is to say~~ the stimulation oscillation has ~~a~~ constant amplitude).

As has already been mentioned, movement or rotation of the Coriolis gyro 1 results in Coriolis forces (indicated by ~~the term~~ FC•cos(ω1•t) in the drawing) that ~~which~~ couple the first resonator 3 to the second resonator 4, causing ~~and thus cause~~ the second resonator 4 to oscillate. A resultant read oscillation at ~~the~~ frequency ω2 is tapped off~~,~~ so that a corresponding tapped-off read oscillation signal (read signal) is supplied to both the

third and fourth control loops. In the third control loop, this signal is demodulated by means of the third demodulator 15, the sum frequencies ~~are~~ removed by the third low-pass filter 16, and the low-pass-filtered signal ~~is~~ supplied to a ~~the~~ quadrature regulator 17 whose output ~~signal~~ is applied to the third modulator 22 so ~~such~~ that corresponding quadrature components of the read oscillation are reset. Analogously ~~to this~~, the tapped-off read oscillation signal is demodulated in the fourth control loop by means of a ~~the~~ fourth demodulator 19. It then passes through a ~~the~~ fourth low-pass filter 20 and ~~the correspondingly low-pass-~~filtered signal is applied ~~on the one hand~~ to a ~~the~~ rotation rate regulator 21. The ~~whose~~ output ~~signal~~ of the rotation rate regulator 21 is proportional to the instantaneous rotation rate and ~~which~~ is passed as the rotation rate measurement ~~result~~ to a rotation rate output 24 and is applied ~~on the other hand~~ to the second modulator 18, which resets the corresponding rotation rate components of the read oscillation.

A Coriolis gyro 1 as described above can ~~may~~ be operated ~~not only~~ in either a double-resonant form or ~~but also~~ in a form in which it is not double-resonant. When ~~If~~ the Coriolis gyro 1 is operated in a double-resonant form, ~~then~~ the frequency of $\omega 2$ of the read oscillation is approximately equal to the frequency $\omega 1$ of the stimulation oscillation. ~~While~~ In contrast, when it is operated in a form in which it is not double-resonant, the frequency $\omega 2$ of the read oscillation differs from the frequency $\omega 1$ of the stimulation oscillation. In the case of double-resonance, the output signal from the fourth low-pass filter 20 contains ~~corresponding~~ information about the rotation rate, while, when it is not operated in ~~a~~ double-resonant form, ~~on the other hand, it is~~ the output signal from the

third low-pass filter 16 contains the rotation rate information. A doubling switch 25 which selectively connects the outputs of the third and fourth low-pass filters 16, 20 to the rotation rate regulator 21 and to the quadrature regulator 17 is provided for switching ~~in order to switch~~ between the double-resonant and non- double resonant modes.

When the Coriolis gyro 1 is ~~intended to be~~ operated in a double-resonant form, the frequency of the read oscillation is ~~must be~~ tuned, as mentioned, to that ~~the frequency~~ of the stimulation oscillation. This may be done ~~achieved~~ to the resonator 2, for example by mechanical means, in which material is removed from the mass system. As an alternative ~~to this~~, the frequency of ~~the~~ read oscillation can ~~also~~ be set by means of an electrical field in which the resonator 2 is mounted to ~~so that it can~~ oscillate (i.e., by changing the electrical field strength). It is thus possible to tune the frequency of the read oscillation to the frequency of the stimulated oscillation electronically during operation of the Coriolis gyro 1 ~~as well~~.

SUMMARY AND OBJECTS OF THE INVENTION

It is an object of ~~The object on which~~ the invention ~~is based is~~ to provide a method for electronically tuning ~~by means of which~~ the frequency of the read oscillation in a Coriolis gyro ~~can be electronically tuned~~ to that the frequency of the stimulation oscillation.

The invention addresses the preceding and other objects by providing, in a first aspect, a method for electronically tuning the frequency of the read oscillation in a Coriolis gyro. A disturbance force is applied to the resonator of the gyro so that the stimulation oscillation

remains essentially uninfluenced and the read oscillation is changed such that a read signal that represents the read oscillation contains a corresponding disturbance component. According to the method, the frequency of the read oscillation is controlled so that the magnitude of the disturbance component in the read signal is made as small as possible.

In a second aspect, the invention provides a Coriolis gyro having a rotation rate control loop and a quadrature control loop. Such gyro includes a device for electronic tuning of the frequency of the read oscillation to that of the stimulation oscillation.

Such device includes a disturbance unit that passes a disturbance signal to either the rotation rate control loop or to the quadrature control loop. A disturbance signal detection unit determines a disturbance component contained in a read signal produced by the disturbance signal. A central unit controls the frequency of the read oscillation so that the magnitude of the disturbance component contained in the read signal is a small as possible.

The preceding and other features of the invention will become further apparent from the detailed description that follows. Such description is accompanied by a set of drawings. Numerals of the drawings, corresponding to those of the written description, point to the features of the invention with like numerals referring to like features throughout.

~~One exemplary embodiment of the invention will be explained in more detail in the following text with reference to the accompanying figures, in which:~~

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a Coriolis gyro based on the method of the invention; and

Figure 2 is a schematic diagram of a Coriolis gyro in accordance with the prior art.

~~First of all, one exemplary embodiment of the method according to the invention will be explained in more detail with reference to Figure 1. In this case, parts and/or devices which correspond to those in Figure 2 are identified by the same reference symbols, and will not be explained once again.~~

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 is a schematic diagram of a Coriolis gyro 1' based on the method of the invention. The Coriolis gyro 1' ~~is~~ additionally includes ~~provided with~~ a disturbance unit 26, a demodulation unit 27 and a read oscillation frequency regulator 28.

The disturbance unit 26 generates ~~produces~~ an alternating signal of ~~at a~~ frequency ωmod that ~~which~~ is added to the output of ~~signal from~~ a quadrature regulator 21 (i.e. ~~that is to say~~ at the force output from the quadrature control loop). The collated signal ~~which is~~ obtained in this way is supplied to a (third) modulator 22 whose ~~corresponding~~ output ~~signal~~ is applied to a force transmitter (not shown), and, thus, to the resonator 2. As long as ~~Provided that~~ the frequency of the read oscillation does not essentially match that ~~the frequency~~ of the stimulation oscillation, the alternating signal ~~is~~ produced by the disturbance modulation unit 26 is observed, after

"passing through" the resonator 2, in the form of a disturbance component on the tapped-off read oscillation signal.

The tapped-off read oscillation signal is subjected to a demodulation process ~~which is~~ (carried out by means of a fourth demodulator 19) and ~~is~~ supplied to a fourth low-pass filter 20 whose output ~~signal~~ is applied both to a rotation rate regulator 21 and to the demodulation unit 27. The signal ~~which is~~ supplied to the demodulation unit 27 is demodulated with ~~using~~ a modulation frequency ωmod that ~~which~~ corresponds to the frequency of the alternating signal ~~which is~~ produced by the disturbance unit 26. The disturbance component (or the signal which represents the disturbance) is thus determined.

The demodulation unit 27 in this example can thus be regarded as a disturbance signal detection unit. An output signal from the demodulation unit 27 is supplied to the read oscillation frequency regulator 28 that ~~which~~ sets the frequency of the read oscillation as a function of it so that ~~this such that~~ the output signal from the demodulation unit 27 (i.e. ~~that is to say~~ the strength of the observed disturbance component) is a minimum. When a minimum ~~such as this~~ has been reached, then the frequencies of the stimulation oscillation and the read oscillation essentially match. The signal supplied to the demodulation unit 27 may also, as an alternative to the signal ~~which is~~ supplied to the rotation rate regulator 21, be the signal that ~~which~~ the rotation rate regulator 21 emits.

As ~~already~~ mentioned above, and as an alternative ~~to this~~, the alternating signal ~~which is~~ produced by the disturbance unit 26 can also be added to an output ~~signal~~

~~from~~ of the rotation rate regulator 21. In such ~~this~~ case, the signal supplied to the demodulation unit 27 would be tapped off at the input or output of the quadrature regulator 17.

~~Furthermore~~ In principle, it is also possible to feed the disturbance signal (in this case the alternating signal, although other disturbance signals such as band-limited noise are also possible) into the quadrature control loop at any desired point (not only directly upstream of the third modulator 22, i.e., ~~that is to say~~ at any desired point between the point at which the read oscillation is tapped off and the third modulator 22). Analogous considerations apply to ~~the~~ feeding ~~of~~ the disturbance signal into the rotation rate control loop.

Once the Coriolis gyro 1' has been switched on, it is advantageous to set the modulation frequency ωmod of the alternating signal to a high value ~~in order~~ to quickly achieve coarse control of the read oscillation frequency. It is then possible to switch to a relatively low modulation frequency ωmod ~~in order~~ to set resonance of the read oscillation precisely. Further ~~Furthermore~~, the amplitude of the modulation frequency ωmod can be greatly reduced a certain amount of time after stabilization of the rotation rate regulator 21 and/or of the quadrature regulator 17. Since the alternating signal at the output of the rotation rate control loop, ~~that is to say~~ (i.e. the third control loop) is compensated, there is generally no need for any blocking filter for the modulation frequency ωmod in the rotation rate control loop.

At the same time, the rotation rate regulator 21 associates ~~has the effect of associating~~ the third demodulator 15 and the fourth demodulator 19 in ~~the correct~~

phase with the force transmitters for the rotation rate control loop (cosine-wave forces) and the quadrature control loop (sine-wave forces). The rotation rate (fourth control loop) and quadrature control loop (third control loop) can thus be separated even when phase shifts occur in the analog electronics of the Coriolis gyro 1'. These ~~which in particular~~ can occur, particularly as a function of ~~the~~ temperature. In general, a high bias will occur in the quadrature control loop. If this control loop and the rotation rate control loop are not clearly separated from one another, such ~~this~~ bias will also appear in the rotation rate control loop.

Even when electronic frequency matching between the stimulation ~~oscillation~~ and the read oscillations is not desirable, the described control mechanism can be used to insure that the quadrature control loop and the rotation rate control loop are orthogonal. In this case, the controlled variable is the reference phase of the third and ~~of the~~ fourth demodulators ~~demodulator~~ 15, 19, which are respectively "responsible" for quadrature components and rotation rate components of the read oscillation. This control process is preferably carried out digitally in a signal processor (DSP) and renders the Coriolis gyro insensitive to phase shifts in the analog electronics.

In ~~the case of~~ a second, alternative method for electronic tuning ~~of~~ the frequency of the read oscillation to that ~~the frequency~~ of the stimulation oscillation in a Coriolis gyro, a disturbance force is applied to the resonator of the Coriolis gyro so that ~~in such a way that~~(a) the stimulation oscillation remains essentially uninfluenced, and (b) the read oscillation is changed such that a read signal which represents the read oscillation contains a corresponding disturbance component. In this

way, ~~wherein~~ the frequency of the read oscillation is controlled so ~~such~~ that any phase shift between a disturbance signal that ~~which~~ produces the disturbance force and the disturbance component ~~which is~~ contained in the read signal is as small as possible. In this case, ~~the wording~~ "resonator" refers to ~~means~~ the entire mass system (or part of it) that ~~which~~ can be caused to oscillate in the Coriolis gyro (i.e., that part of the Coriolis gyro that is annotated with reference numeral ~~number~~ 2).

A significant discovery on which the second alternative method is based is that the "time for disturbance to pass through" the resonator (i.e., ~~that is to say~~ an artificial change to the read oscillation resulting from the application of appropriate disturbance forces to the resonator), ~~the resonator, that is to say~~ the time that ~~which~~ passes from the effect of the disturbance on the resonator until the disturbance is tapped off as part of the read signal, is dependent on the frequency of ~~the~~ read oscillation. The shift between the phase of the disturbance signal and the phase of the disturbance component signal ~~which is~~ contained in the read signal is thus a measure of the frequency of the read oscillation. It can be shown that the phase shift assumes a minimum when the frequency of the read oscillation essentially matches that ~~the frequency~~ of the stimulation oscillation. If the frequency of the read oscillation is controlled such that the phase shift assumes a minimum, then the frequency of the read oscillation is at the same time essentially matched to the frequency of the stimulation oscillation.

In a third alternative embodiment of the method for electronic tuning of the frequency of the read oscillation to that ~~the frequency~~ of the stimulation oscillation in a Coriolis gyro, a disturbance force is

applied to the resonator of the Coriolis gyro ~~it~~ such that (a) the stimulation oscillation remains essentially uninfluenced and (b) the read oscillation is changed so ~~such~~ that a read signal representing ~~which represents~~ the read oscillation contains a corresponding disturbance component. ~~With~~ The disturbance force is ~~being~~ defined as the ~~that~~ force ~~which is~~ caused by the signal noise in the read signal. The frequency of the read oscillation, in such ~~this~~ case, is controlled so ~~such~~ that the magnitude of the disturbance component ~~which is~~ contained in the read signal (i.e., ~~that is to say~~ the noise component) is as small as possible.

~~The word~~ "Resonator" in this case refers to ~~means~~ the entire mass system that ~~which~~ can be caused to oscillate in the Coriolis gyro (i.e., ~~that is to say~~ that part of the Coriolis gyro which is identified by the reference number 2). The essential feature in this case is that the disturbance forces on the resonator change only the read oscillation, but not the stimulation oscillation. With reference to Figure 2, this would mean that the disturbance forces act ~~acted~~ only on the second resonator 4, but not the first resonator 3.

A significant discovery on which the third ~~alternative~~ method is based is that a disturbance signal, in the form of signal noise, which occurs directly in the tapped-off read oscillation signal or at the input of the control loops (rotation rate control loop/quadrature control loop), can be observed to a greater extent in the tapped-off read oscillation signal after "passing through" the control loops and the resonator, the less the frequency of the read oscillation matches the frequency of the stimulation oscillation. The signal noise (the signal noise of the read oscillation tapping-off electronics or the random walk of

the Coriolis gyro) is applied, after "passing through" the control loops, to the force transmitters and thus produces corresponding disturbance forces that ~~which~~ are applied to the resonator and, thus, cause an artificial change in the read oscillation. The "penetration strength" of a disturbance such as this to the tapped-off read oscillation signal is thus a measure of how accurately the frequency of the read oscillation is matched to that of the stimulation oscillation. Thus, if the frequency of the read oscillation is controlled so ~~such~~ that the penetration strength assumes a minimum (i.e., ~~that is to say~~ the magnitude of the disturbance component which is contained in the tapped-off read oscillation signal, that is ~~to say~~ the noise component) ~~is a minimum~~ then the frequency of the read oscillation is at the same time ~~thus~~ matched to the frequency of the stimulation oscillation.

The first method ~~according to the invention which was~~ described for electronic tuning of the read oscillation frequency can be combined as required with the second ~~alternative~~ method and/or with the third ~~alternative~~ method. For example, it is possible to use the method described first while the Coriolis gyro is being started up (rapid transient response), and then to use the third ~~alternative~~ method (slow control process) in steady-state operation. ~~Specific technical refinements as well as further details relating to the methods can be found by those skilled in the art in the patent applications "Verfahren zur elektronischen Abstimmung der Ausleseschwingungfreqkuenz eines Corioliskreisels", [Method for electronic tuning of the read oscillation frequency of a Coriolis gyro], LTF-191-DE and LTF-192-DE from the same applicant, in which, respectively, the second alternative method and the third alternative method are described. The entire contents of the patent applications LTF-191-DE/LTF-192-D2 are thus hereby included~~

~~in the description.~~

~~This object is achieved by the method as claimed in the features of patent claim 1. The invention furthermore provides a Coriolis gyro as claimed in patent claim 11. Advantageous refinements and developments of the idea of the invention can be found in the respective dependent claims.~~

~~According to the invention, in the case of a method for electronic tuning of the read oscillation to the frequency of the stimulation oscillation in a Coriolis gyro, the resonator of the Coriolis gyro has a disturbance force applied to it such that a) the stimulation oscillation remains essentially uninfluenced and b) the read oscillation is changed such that a read signal which represents the read oscillation contains a corresponding disturbance component, wherein the frequency of the read oscillation is controlled such that the magnitude of the disturbance component which is contained in the read signal is as small as possible.~~

A major discovery on which the invention is based is that an artificial change to the read oscillation in the rotation rate channel or quadrature channel is visible to a greater extent, in particular in the respective channel which is orthogonal to it ~~this~~, the less the frequency of the read oscillation matches the frequency of the stimulation oscillation. The "penetration strength" of a disturbance such as this to the tapped-off read oscillation signal (in particular to the orthogonal channel) is thus a measure of how accurately the frequency of the read oscillation is matched to the frequency of the stimulation oscillation. Thus, if the frequency of the read oscillation is controlled so ~~such~~ that the penetration strength assumes a minimum (i.e., ~~that is to say~~ such that the magnitude of the disturbance component which is contained in the tapped-

off read oscillation signal is a minimum) then the frequency of the read oscillation is at the same time essentially matched to the frequency of the stimulation oscillation. The significant factor in this case is that the disturbance forces on the resonator change only the read oscillation, but not the stimulation oscillation. With reference to Figure 2, this means that the disturbance forces act only on the second resonator 4, but not on the first resonator 3.

The disturbance force is preferably produced by a disturbance signal that ~~which~~ is supplied to appropriate force transmitters, or is added to signals which are supplied to the force transmitters. For ~~By way of~~ example, a disturbance signal can be added to the respective control/reset signals for control/compensation of the read oscillation, ~~in order~~ to produce the disturbance force.

The disturbance signal is preferably an alternating signal (e.g. ~~for example~~ a superposition of sine-wave signals and cosine-wave signals). This disturbance signal is generally at a fixed disturbance frequency so that the disturbance component of the tapped-off read oscillation signal can be determined by means of an appropriate demodulation process~~, which is~~ carried out at the ~~said~~ disturbance frequency. One alternative is to use band-limited noise instead of an alternating signal. In this case, the disturbance component is demodulated from the read signal by correlation of the disturbance signal (noise signal) with the read signal (the signal which contains the disturbance component). The bandwidth of the noise in this case is dependent on the characteristics of the resonator 2 and of the control loops.

The method described above can be used for both an open loop and a closed loop Coriolis gyro. In the latter

case, the disturbance signal is preferably added to the respective control/reset signals for control/compensation of the read oscillation. For ~~By way of~~ example, the disturbance signal can be added to the output signal from a rotation rate control loop, and the disturbance component can be determined from a signal that ~~which~~ is applied to or ~~is~~ emitted from a quadrature regulator in a quadrature control loop. Conversely, the disturbance signal can be added to the output signal from the quadrature control loop, and the disturbance component can be determined from a signal that ~~which~~ is applied to or is emitted from a rotation rate regulator in the rotation rate control loop. As an alternative ~~to this~~, the disturbance signal can be added to the output signal from the quadrature control loop and the disturbance component ~~can be~~ determined from a signal which is applied to, or emitted from, a quadrature regulator in the quadrature control loop. ~~Furthermore~~ It is also possible to add the disturbance signal to the output signal from the rotation rate control loop, and to determine the disturbance component from a signal which is applied to, or emitted from, a rotation rate regulator in the rotation rate control loop. The expression "read signal" covers all signals that ~~which~~ are referred to in this paragraph and from which the disturbance component can be determined. In addition, the expression "read signal" covers the tapped-off read oscillation signal.

The frequency of the read oscillation (i.e. the force transmission of the control forces which are required for frequency control) is in this case controlled by controlling the intensity of an electrical field in which at least a part of the resonator oscillates, with an electrical attraction force. Such force, preferably non-linear, is established between the resonator and an opposing piece, fixed to the frame and surrounding.

~~The invention also provides a Coriolis gyro which has a rotation rate control loop and a quadrature control loop and is characterized by a device for electronic tuning of the frequency of the read oscillation to the frequency of the stimulation oscillation.~~

~~The device for electronic tuning in this case has:~~

- ~~a disturbance unit which passes a disturbance signal to the rotation rate control loop or to the quadrature control loop,~~
- ~~a disturbance signal detection unit, which determines a disturbance component which is contained in a read signal (which represents the read oscillation) and has been produced by the disturbance signal, and~~
- ~~a control unit, which controls the frequency of the read oscillation such that the magnitude of the disturbance component which is contained in the read signal is as small as possible.~~

~~The disturbance unit preferably passes the disturbance signal to the quadrature control loop, with the disturbance signal detection unit then determining the disturbance component from a signal which is applied to a rotation rate regulator in the rotation rate control loop, or is emitted from it. Conversely, the disturbance unit can pass the disturbance signal to the rotation rate control loop, and the disturbance signal detection unit can determine the disturbance component from a signal which is applied to a quadrature regulator in the quadrature control loop, or is emitted from it. Furthermore, the disturbance unit can pass the disturbance signal to the rotation rate control loop, and the disturbance signal detection unit can determine the disturbance component from a signal which is applied to a rotation rate regulator in the rotation rate control loop, or is emitted from it. A further alternative is for the~~

~~disturbance signal to be passed by the disturbance unit to the quadrature control loop with the disturbance signal detection unit then determining the disturbance component from a signal which is applied to a quadrature regulator in the quadrature control loop, or is emitted from it.~~

~~The disturbance signal is preferably an alternating signal at a fixed disturbance frequency, with the device for electronic tuning of the read oscillation frequency and stimulation oscillation frequency in this case advantageously having a demodulation unit which demodulates the read signal at the fixed disturbance frequency, and thus determines the disturbance component which is contained in the read signal. Fundamentally, the disturbance signal may be introduced into the control loops (the rotation rate control loop and a quadrature control loop) at any desired point.)~~

While the invention has been described with reference to its presently-preferred embodiment, it is not limited thereto. Rather, the invention is limited only insofar as it is defined by the following set of patent claims and includes within its scope all equivalents thereof.

~~Patent Claims~~

What is claimed is:

1. A method for electronic tuning of the frequency of the read oscillation to the frequency of the stimulation oscillation in a Coriolis gyro (1'), wherein
- the resonator (2) of the Coriolis gyro (1') has a disturbance force applied to it such that
a) the stimulation oscillation remains essentially uninfluenced, and
b) the read oscillation is changed such that a read signal, which represents the read oscillation, contains a corresponding disturbance component, wherein
- the frequency of the read oscillation is controlled such that the magnitude of the disturbance component, which is contained in the read signal, is as small as possible.

2. The method as claimed in claim 1, characterized in that the disturbance force is produced by a disturbance signal which is added to the respective control/reset signals for control/compensation of the read oscillation.

3. The method as claimed in claim 1 or 2, characterized in that the disturbance signal is an alternating signal.

4. The method as claimed in claim 3, characterized in that the disturbance signal is at a fixed disturbance frequency, and the disturbance component is determined from the read signal by demodulation of the read signal at the fixed disturbance frequency.

5. The method as claimed in claim 1 or 2, characterized in that the disturbance signal is band-limited noise, and the disturbance component is demodulated from the read signal by correlation of the disturbance signal with the read signal.

6. The method as claimed in one of claims 2 to 5, characterized in that the disturbance signal is added to the output signal from the rotation rate control loop, and the disturbance component is determined from a signal which is applied to a quadrature regulator (17) in the quadrature control loop, or is emitted from it.

7. The method as claimed in one of claims 2 to 5, characterized in that the disturbance signal is added to the output signal from the quadrature control loop, and the disturbance component is determined from a signal which is applied to a rotation rate regulator (21) in the rotation rate control loop, or is emitted from it.

8. The method as claimed in one of claims 2 to 5, characterized in that the disturbance signal is added to the output signal from the quadrature control loop, and the disturbance component is determined from a signal which is applied to a quadrature regulator (17) in the quadrature control loop, or is emitted from it.

9. The method as claimed in one of claims 2 to 5, characterized in that the disturbance signal is added to the output signal from the rotation rate control loop, and the disturbance component is determined from a signal which is applied to a rotation rate regulator (21) in the rotation rate control loop, or is emitted from it.

10. The method as claimed in one of the preceding claims, characterized in that the frequency of the read oscillation is controlled by controlling the intensity of an electrical field in which a part of the resonator (2) of the Coriolis gyro (1') oscillates.

11. A Coriolis gyro (1') which has a rotation rate control loop and a quadrature control loop, characterized by a device for electronic tuning of the frequency of the read oscillation to the frequency of the stimulation oscillation, having:
- a disturbance unit (26) which passes a disturbance signal to the rotation rate control loop or to the quadrature control loop,
- a disturbance signal detection unit (27), which determines a disturbance component which is contained in a read signal (which represents the read oscillation) and has been produced by the disturbance signal, and
- a control unit (28), which controls the frequency of the read oscillation such that the magnitude of the disturbance component, which is contained in the read signal, is as small as possible.

12. The Coriolis gyro (1') as claimed in claim 11, characterized in that the disturbance unit (26) passes the disturbance signal to the rotation rate control loop, and the disturbance signal detection unit (27) determines the disturbance component from a signal which is applied to a quadrature regulator (17) in the quadrature control loop, or is emitted from it.

13. The Coriolis gyro (1') as claimed in claim 11, characterized in that the disturbance unit (26) passes the disturbance signal to the quadrature control loop, and the disturbance signal detection unit (27) determines the disturbance component from a signal which is applied to a rotation rate regulator (21) in the rotation rate control loop, or is emitted from it.

14. The Coriolis gyro (1') as claimed in claim 11, characterized in that the disturbance unit (26) passes the disturbance signal to the rotation rate control loop, and the disturbance signal detection unit (27) determines the disturbance component from a signal which is applied to a rotation rate regulator (21) in the rotation rate control loop, or is emitted from it.

15. The Coriolis gyro (1') as claimed in claim 11, characterized in that the disturbance unit (26) passes the disturbance signal to the quadrature control loop, and the disturbance signal detection unit (27) determines the disturbance component from a signal which is applied to a quadrature regulator (17) in the quadrature control loop, or is emitted from it.

16. The Coriolis gyro (1') as claimed in one of claims 11 to 15, characterized in that the disturbance signal is an alternating signal at a fixed disturbance frequency, and the device for electronic tuning of the read oscillation frequency and stimulation oscillation frequency has a demodulation unit (27), which demodulates the read signal at the fixed disturbance frequency and thus determines the disturbance component which is contained in the read signal.

ABSTRACT

In a method for electronic tuning of the frequency of the read oscillation to the frequency of the stimulation oscillation in a Coriolis gyro ~~(1'') according to the invention~~, the resonator ~~(2)~~ of the Coriolis gyro ~~(1'')~~ has a disturbance force applied to it such that the stimulation oscillation remains essentially uninfluenced. ~~With~~ The read oscillation is ~~being~~ changed so ~~such~~ that a read signal that ~~which~~ represents the read oscillation contains a corresponding disturbance component. The frequency of the read oscillation is controlled so ~~such~~ that the magnitude of the disturbance component ~~which is~~ contained in the read signal is a minimum.